The listing of claims will replace all prior versions, and listings, of claims in the application:

Listing of Claims:

1. (currently amended) A method of obtaining magnetic resonance signals with signal separation for at least two chemical species in a heterogeneous magnetic field **using rapid gradient echo imaging**, comprising the steps of:

a) obtaining first magnetic resonance signals from pixels in an object having at least two chemical species using a first repetition time and a first echo time,

b) obtaining at least second and third magnetic resonant signals from the pixels using second and third echo times,

c) determining a signal estimate **for each species and** for each pixel by combining all signals for the pixel using a linear least squares fitting **of the signals from each pixel** to decompose the chemical species, assuming a first value of field heterogeneity (ψ_0),

d) calculating a first error to the field heterogeneity,

e) repeating step c) using the first value of field heterogeneity and the error from step d),

f) repeating step d) to calculate a second error to the field heterogeneity, and

g) updating the value of field heterogeneity and repeating steps c) and d) until an acceptable error is calculated.

2. (original) The method as defined by claim 1 wherein M chemical species are present and step b) includes obtaining at least M+1 magnetic resonance signals for each pixel.

3. (original) The method as defined by claim1 wherein fat and water are two chemical species and step b) includes obtaining three magnetic resonance signals.

4. (original) The method as defined by claim 1 wherein in step b) the magnetic resonance signals at time, n=1 to N, for species, j =1 to M, having real, R, and imaginary, I, parts is given by:

$$\hat{s}_n = \hat{s}_n^R + i\hat{s}_n^I = \sum_{j=1}^{M}\left(\rho_j^R c_{jn} - \rho_j^I d_{jn}\right) + i\sum_{j=1}^{M}\left(\rho_j^R d_{jn} + \rho_j^I c_{jn}\right)$$

and a least squares fitting of all signals is given by:

$$\hat{\boldsymbol{\rho}} = (\mathbf{A}^T\mathbf{A})^{-1}\mathbf{A}^T\hat{\mathbf{S}}$$

where A is a known matrix for M species.

5. (original) The method as defined by claim 4 wherein:

$$\mathbf{A} = \begin{bmatrix} c_{11} & -d_{11} & c_{21} & -d_{21} & \ldots & c_{M1} & -d_{M1} \\ c_{12} & -d_{12} & c_{22} & -d_{22} & \ldots & c_{M2} & -d_{M2} \\ \ldots & \ldots & \ldots & \ldots & \ldots & \ldots & \ldots \\ c_{1N} & -d_{1N} & c_{2N} & -d_{2N} & \ldots & c_{MN} & -d_{MN} \\ d_{11} & c_{11} & d_{21} & c_{21} & \ldots & d_{M1} & c_{M1} \\ d_{12} & c_{12} & d_{22} & c_{22} & \ldots & d_{M2} & c_{M2} \\ \ldots & \ldots & \ldots & \ldots & \ldots & \ldots & \ldots \\ d_{1N} & c_{1N} & d_{2N} & c_{2N} & \ldots & d_{MN} & c_{MN} \end{bmatrix}$$

where $c_n^{fw} = \cos(2\pi\Delta f_{fw} t_n)$, $d_n^{fw} = \sin(2\pi\Delta f_{fw} t_n)$, $g_n^R = 2\pi t_n\left(-\hat{\rho}_w^I - \hat{\rho}_f^R d_n - \hat{\rho}_f^I c_n\right)$ and $g_n^I = 2\pi t_n\left(\hat{\rho}_w^R + \hat{\rho}_f^R c_n - \hat{\rho}_f^I d_n\right)$ are the matrix elements.

6. (original) The method as defined by claim 4 wherein error to the field heterogeneity is given by:

$$\mathbf{y} = (\mathbf{B}^T\mathbf{B})^{-1}\mathbf{B}^T\hat{\hat{\mathbf{S}}}$$

where B is a matrix given by:

$$\mathbf{B} = \begin{bmatrix} g_{11}^R & c_{11} & -d_{11} & c_{21} & -d_{21} & \ldots & c_{M1} & -d_{M1} \\ g_{12}^R & c_{12} & -d_{12} & c_{22} & -d_{22} & \ldots & c_{M2} & -d_{M2} \\ \ldots & \ldots & \ldots & \ldots & \ldots & \ldots & \ldots & \ldots \\ g_{1N}^R & c_{1N} & -d_{1N} & c_{2N} & -d_{2N} & \ldots & c_{MN} & -d_{MN} \\ g_{11}^I & d_{11} & c_{11} & d_{21} & c_{21} & \ldots & d_{M1} & c_{M1} \\ g_{12}^I & d_{12} & c_{12} & d_{22} & c_{22} & \ldots & d_{M2} & c_{M2} \\ \ldots & \ldots & \ldots & \ldots & \ldots & \ldots & \ldots & \ldots \\ g_{1N}^I & d_{1N} & c_{1N} & d_{2N} & c_{2N} & \ldots & d_{MN} & c_{MN} \end{bmatrix}$$

where

$\mathbf{y} = \left[\Delta\psi \quad \Delta\rho_1^R \quad \Delta\rho_1^I \quad \Delta\rho_2^R \quad \Delta\rho_2^I \quad \ldots \quad \Delta\rho_M^R \quad \Delta\rho_M^I\right]^T$, $g_{jn}^R = 2\pi t_n \sum_{j=1}^{M}\left(-\hat{\rho}_j^R d_{jn} - \hat{\rho}_j^I c_{jn}\right)$ and

$g_{jn}^I = 2\pi t_n \sum_{j=1}^{M}\left(\hat{\rho}_j^R c_{jn} - \hat{\rho}_j^I d_{jn}\right)$.

7. (original) The method as defined by claim 6 wherein step a) includes obtaining signals from a single coil.

8. (original) The method as defined by claim 6 wherein step a) includes obtaining signals from a plurality of coils and steps b) through g) are performed for signals from each coil, and further including the step of:

h) combining field heterogeneity as determined from signals for each coil.

9. (original) The method as defined by claim 8 wherein field heterogeneity is determined by weighting contributions from each coil.

10. (original) The method as defined by claim 9 wherein the weighting contribution from each coil is a function of the square of the magnitude of the image contributed by that coil.

11. (original) The method as defined by claim 10 where for each pixel, at position r, the combined field map is:

$$\psi_c(\mathbf{r}) = \frac{\sum_{p=1}^{P} \psi_p(\mathbf{r}) \left| s_p \right|^2}{\sum_{p=1}^{P} \left| s_p \right|^2}$$

where P coils collect P independent images.

12. (original) The method as defined by claim 11 wherein the combined field heterogeneity from step h) is smoothed by passing through a low pass filter.

13. (original) The method as defined by claim 11 wherein M images of each species are obtained using signals from each of M coils and the combined field heterogeneity, and then combining the M images using a square root of the sum of the squares of the images.

14. (original) The method as defined by claim 1 wherein step a) includes obtaining signals from a plurality of coils and steps b) through g) are performed for signals from each coil, and further including the step of:

h) combining field heterogeneity as determined from signals for each coil.

15. (original) The method as defined by claim 14 wherein field heterogeneity is determined by weighting contributions from each coil.

16. (original) The method as defined by claim 15 wherein the weighting contribution from each coil is a function of the square of the magnitude of the image contributed by that coil.

17. (original) The method as defined by claim 16 where for each pixel, at position r, the combined field map is:

$$\psi_c(\mathbf{r}) = \frac{\sum_{p=1}^{P} \psi_p(\mathbf{r}) \left| s_p \right|^2}{\sum_{p=1}^{P} \left| s_p \right|^2}$$

where P coils collect P independent images.

18. (original) The method as defined by claim 17 wherein the combined field heterogeneity from step h) is smoothed by passing through a low pass filter.

19. (original) The method as defined by claim 17 wherein M images of each species is obtained using signals from each of M coils and the combined field heterogeneity, and then combining the M images using a square root of the sum of the squares of the images.